

Chapter 7

Geology and Soils

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Geology and Soils

This chapter analyzes the proposed action's potential effects related to geology and geologic hazards, including earthquake and landslide hazards. It also discusses the proposed action's potential effects on soil resources. Related discussions are found in Chapter 8 (*Water Resources*), Chapter 10 (*Paleontological Resources*), and Chapter 14 (*Public Health and Environmental Hazards*).

Key sources of data used in the preparation of this chapter include the following.

- Regional geologic maps and fault maps prepared by the California Department of Conservation's California Geological Survey (formerly the Division of Mines and Geology) and U.S. Geological Survey.
- Soils information made available by the Earth System Science Center at Pennsylvania State University, based on soils mapping by the Soil Conservation Service (SCS) (now the Natural Resources Conservation Service [NRCS]).

Specific reference information is provided in the text.

Affected Environment

Regulatory Framework

Federal Regulations—Clean Water Act Section 402[p]

Amendments to the federal Clean Water Act (CWA) in 1987 added Section 402[p], which created a framework for regulating municipal and industrial storm water discharges under the National Pollutant Discharge Elimination System (NPDES) program. In California, the State Water Resources Control Board is responsible for implementing the NPDES program; pursuant to the state's Porter-Cologne Water Quality Control Act (see discussion in Chapter 8), it delegates implementation responsibility to the state's nine Regional Water Quality Control Boards.

Under the NPDES Phase II Rule, any construction project disturbing 1 acre or more must obtain coverage under the state's General Permit for Storm Water

Discharges Associated with Construction Activity. The purpose of the Phase II rule is to avoid or mitigate the effects of construction activities, including earthwork, on surface waters. To this end, General Construction Permit applicants are required to file a Notice of Intent to Discharge Storm Water with the Regional Water Quality Board that has jurisdiction over the construction area, and to prepare a Storm Water Pollution Prevention Plan (SWPPP) stipulating best management practices (BMPs) that will be in place to avoid adverse effects on water quality.

Additional information on other aspects of the federal Clean Water Act is provided in Chapter 8 (*Water Resources*).

State Regulations and Policies

Alquist-Priolo Earthquake Fault Zoning Act

California's Alquist-Priolo Earthquake Fault Zoning Act (Public Resources Code Sec. 2621 *et seq.*), originally enacted in 1972 as the Alquist-Priolo Special Studies Zones Act and renamed in 1994, is intended to reduce the risk to life and property from surface fault rupture during earthquakes. The Alquist-Priolo Act prohibits the location of most types of structures intended for human occupancy¹ across the traces of active faults and strictly regulates construction in the corridors along active faults (*earthquake fault zones*). It also defines criteria for identifying active faults, giving legal weight to terms such as *active*, and establishes a process for reviewing building proposals in and adjacent to Earthquake Fault Zones.

Under the Alquist-Priolo Act, faults are zoned and construction along or across them is strictly regulated if they are “sufficiently active” and “well-defined.” A fault is considered *sufficiently active* if one or more of its segments or strands shows evidence of surface displacement during Holocene time (defined for purposes of the Act as referring to approximately the last 11,000 years). A fault is considered *well defined* if its trace can be clearly identified by a trained geologist at the ground surface or in the shallow subsurface, using standard professional techniques, criteria, and judgment (Hart and Bryant 1997).

Seismic Hazards Mapping Act

Like the Alquist-Priolo Act, the Seismic Hazards Mapping Act of 1990 (PRC Sections 2690–2699.6) is intended to reduce damage resulting from earthquakes. While the Alquist-Priolo Act addresses surface fault rupture, the Seismic Hazards Mapping Act addresses other earthquake-related hazards, including strong

¹ With reference to the Alquist-Priolo Act, a *structure for human occupancy* is defined as one “used or intended for supporting or sheltering any use or occupancy, which is expected to have a human occupancy rate of more than 2,000 person-hours per year” (California Code of Regulations, Title 14, Div. 2, Section 3601[e]).

groundshaking, liquefaction², and seismically induced landslides. Its provisions are similar in concept to those of the Alquist-Priolo Act: the state is charged with identifying and mapping areas at risk of strong groundshaking, liquefaction, landslides, and other corollary hazards, and cities and counties are required to regulate development within mapped Seismic Hazard Zones.

Under the Seismic Hazards Mapping Act, permit review is the primary mechanism for local regulation of development. Specifically, cities and counties are prohibited from issuing development permits for sites within Seismic Hazard Zones until appropriate site-specific geologic and/or geotechnical investigations have been carried out and measures to reduce potential damage have been incorporated into the development plans.

Local Regulations

Many cities and counties include geologic hazards as a factor in their land use planning, with the result that their general plans and/or zoning ordinances reflect policies specifically aimed at reducing risk to life and property as a result of seismic and other types of geologic hazards. All of the counties in the action area (San Joaquin, Stanislaus, Mariposa, Merced, Madera, Fresno, Tulare, Kings, and Kern) have developed general plan goals that specifically address reduction of geologic hazards.

In California, earthwork and construction activities are regulated at the local jurisdiction level through a multi-stage permitting process—grading permits are required for most types of earthwork, and additional permits are typically needed for various types of construction.

The purpose of local jurisdiction permit review is to ensure that proposed earthwork will meet the jurisdiction's adopted codes and standards. Most jurisdictions in California have adopted either the Uniform Building Code (UBC) or the California Building Code (CBC) as a minimum standard. The UBC was specifically developed to foster consistency in building laws across the nation by offering local jurisdictions, agencies, and organizations adequate minimum standards to guide local regulation of design and construction. The CBC expands on the UBC by providing more stringent standards addressing reduction of earthquake risk to structures in this seismically active state; however, many jurisdictions have evaluated the UBC as providing adequate protection.

Portions of the UBC that are particularly relevant to geology and geologic hazards include Chapter 16 Division IV (*Structural Design Requirements—Earthquake Design*) and Appendix Chapter 16 (*Structural Forces*, including seismic loading); Chapter 18 (*Foundations and Retaining Walls*); Appendix Chapter 18 (*Waterproofing and Dampproofing Foundations*); Appendix Chapter

² *Liquefaction* is a phenomenon in which the strength and stiffness of a soil are reduced by earthquake shaking or other rapidly applied loading. Liquefaction and related types of ground failure are of greatest concern in areas where well-sorted sandy unconsolidated sediments are present in the subsurface and the water table is comparatively shallow.

31 Division I (*Flood-Resistant Construction*); and Chapter 33 (*Site Work, Demolition, and Grading*), together with Appendix Chapter 33 (*Excavation and Grading*). Chapter 33 of the Uniform Building Code specifically exempts excavation for utilities installation from the grading permit process, even where the chapter has been adopted by the local jurisdiction. However, as discussed in the following section, PG&E adheres to the UBC's earthwork standards where they are not in conflict with or superseded by CPUC regulations.

Depending on the extent, nature, and location of proposed earthwork and construction, the local jurisdiction permit process may require preparation of a site-specific geotechnical investigation, sometimes called a soils report. In some cases, this is required by state regulations (see discussion of Alquist-Priolo and Seismic Hazards Mapping Acts above). It may also be required by the UBC or CBC. The purpose of a site-specific geotechnical investigation is to provide a geologic basis for the development of appropriate project design. Geotechnical investigations typically assess bedrock and Quaternary geology, geologic structure, soils, and previous history of excavation and fill placement; as appropriate, they may also include information specifically addressing the stipulations of the Alquist-Priolo Act, the Seismic Hazards Mapping Act, and/or local regulations.

Engineering and Construction Codes and Standards for PG&E Activities

Design and construction of PG&E facilities is governed by a variety of codes and standards. A number of these specifically regulate topics relevant to geology and geotechnical engineering, such as earthwork standards and seismic safety, including the following.

- **CPUC General Order 95** provides general standards for design and construction of overhead electric transmission and distribution lines.
- **CPUC General Order 112E** provides general standards for design, construction, testing, maintenance and operation of natural gas piping systems.
- **“IEEE 693” *Recommended Practices for Seismic Design of Substations*** contains guidelines for earthquake-resistant substation design and construction. The IEEE (Institute of Electrical and Electronics Engineers, Inc.) is an international professional organization and a widely recognized authority in the development of industry standards for electrical engineering and electric power generation and transmission.
- **The UBC**—as discussed in *Local Regulations* above, the UBC is voluntarily adopted by jurisdictions and agencies. PG&E adheres to the earthwork standards in UBC Chapter 33 and Appendix Chapter 33 where they are not superseded by CPUC regulations.

Existing Conditions

The following sections describe the physiographic setting, geomorphology, and geology of the action area, with an emphasis on Quaternary geology and geologic hazards.

Physiography

The action area is located almost entirely within the Great Valley geomorphic province. As described in Chapter 1, it also includes adjacent low-lying portions of the Sierra Nevada and Coast Range foothills.

The Great Valley, also called the Central Valley, is a nearly flat alluvial plain that lies between the Sierra Nevada on the east and the Coast Ranges on the west. Its south end is defined by the Tehachapi Mountains north of Los Angeles, and its north end is defined by the Klamath Mountains. The valley has an average width of about 50 miles and is about 400 miles long overall. The Great Valley is subdivided into the Sacramento Valley to the north and the San Joaquin Valley to the south; the Sacramento Valley is drained by the south-flowing Sacramento River and the San Joaquin Valley is drained by the generally north-flowing San Joaquin River. The two rivers meet at the Sacramento–San Joaquin Delta, which empties into San Francisco Bay, ultimately connecting with the Pacific Ocean via the Golden Gate (Norris and Webb 1990, Harden 1998).

The elevation of the Valley floor ranges from a few hundred feet to about 1,000 feet above mean sea level (MSL) (Hackel 1966). Most of the action area is located on valley-floor topography with slopes of 0–2%. However, the east and west margins of the area are dominated by undulating foothills topography, where slopes as steep as 15–30% are common. Artificially induced land subsidence has been a concern in both the southern San Joaquin Valley and the Sacramento–San Joaquin Delta region. Principal causes of subsidence in the south include groundwater overdraft, leading to compaction and settling of over-exploited aquifer sediments; and excess irrigation, resulting in consolidation of dry near-surface deposits. In the Delta region, subsidence has been associated with accelerated decomposition of peat beds resulting from conversion of wetlands to agricultural uses (Poland and Everson 1966, Poland et al. 1975, Swanson 1998).

Geologic Framework

The following paragraphs describe the geology of the action area and vicinity, focusing on the Great Valley and adjacent portions of the Coast Ranges and Sierra Nevada.

The **Great Valley** is floored by a thick sequence of sedimentary deposits that range in age from Jurassic through Quaternary. Under the eastern and central portions of the valley, the base of the sequence likely rests on Mesozoic

crystalline rock allied to the plutons of the Sierra Nevada; to the west, basement rocks are believed to be Franciscan metasediments and/or mélangé. Mesozoic sedimentary rocks now in the subsurface record marine deposition. They are overlain by Tertiary strata reflecting marine, estuarine, and terrestrial conditions, which are in turn overlain by Quaternary fluvial and alluvial strata recording uplift and erosion of the Sierra Nevada and Coast Ranges to approximately their present shape (e.g., Norris and Webb 1990).

To the west, **the Coast Ranges geomorphic province** is characterized by an echelon northwest-trending mountain ranges formed over the past 10 million years or less by active uplift related to complex tectonics of the San Andreas fault/plate boundary system (e.g., Norris and Webb 1990, Buising and Walker 1995, Atwater and Stock 1998). The eastern range front is defined by faults that have been interpreted as contractile features associated with shortening along an axis approximately normal to the range front (e.g., Wong et al. 1988, Sowers et al. 1992, Unruh et al. 1992; see also Jennings 1977 for regional mapping), but may also locally accommodate a right-lateral component of motion (e.g., Richesin 1996).

East of the San Andreas fault, the Coast Ranges are broadly antiformal. The core of the uplift consists primarily of metasedimentary rocks and mélangé of the Mesozoic Franciscan Complex (e.g., Jennings 1977). Outcrops of mafic and ultramafic units belonging to the Jurassic Coast Range Ophiolite are also locally present, and are particularly well developed along the Ortigalita fault in the vicinity of Del Puerto Canyon (Wagner et al. 1990, Evarts et al. 1999). Mesozoic ultramafic rocks are also well exposed in the vicinity of San Benito Mountain. The eastern Coast Range range front is flanked by a generally eastward-younging sequence of Cretaceous through Quaternary clastic sedimentary strata. The lower portion of this sequence, where it is present, typically records deep marine deposition, while the upper portion reflects progressive growth and erosional dissection of the Coast Range uplift (Unruh et al. 1992, Richesin 1996). Quaternary alluvial strata accumulated on essentially modern topography buttress against the range front, and are locally folded and/or faulted, particularly along the southern portion of the range front. Active alluvium and older Quaternary terrace deposits are present in the larger active stream valleys throughout the eastern portion of the Coast Ranges (e.g., Jennings, 1977, Wagner et al. 1990, Richesin 1996).

To the east of the action area, **the Sierra Nevada** preserves the dissected remnants of a Mesozoic volcanic arc system similar to the modern Andes. The core of the range consists of plutonic rocks representing the roots of the arc. It is bordered on the eastern margin of the action area by generally westward-younging metavolcanic and metasedimentary rocks ranging in age from Paleozoic to Mesozoic. These strata are in turn overlain by Miocene through Quaternary fluvial and alluvial sediments that pass laterally into valley floor strata, and reflect erosional dissection of the progressively uplifting Sierran massif (Jennings 1977, Bartow 1991).

Soils

This EIS/EIR used the Natural Resource Conservation Service's major land resource area (MLRA) classification system as the basis for characterizing soil resources in the action area. An *MLRA* is a planning unit identified or defined on the basis of similar elevation and topography; climate; water resources; soils; natural vegetation communities; and land uses. An MLRA is typically made up of severally geographically associated land resource units (LRUs). An *LRL*, the basic unit used in the state's land resource mapping, is a geographic area characterized by a particular pattern of soils, climate, water resources, and land uses. An LRU may be one continuous area or may comprise several separate nearby areas (Natural Resources Conservation Services 2004a).

The action area falls within three MLRAs identified by the USDA (Earth System Science Center 1998). Most of the action area is located within MLRA 17, the Sacramento and San Joaquin Valleys. The west and east margins of the action area are located in MLRA 15 (Central California Coast Range) and MLRA 18 (Sierra Nevada foothills) respectively. Table 7-1 summarizes key characteristics of surface soils in each MLRA.

Table 7-1. Soil Characteristics by Major Land Resource Area in Action Area

MLRA	Geographic Extent	Soil Texture	Erosion Hazard	Runoff	Shrink-Swell Hazard
15—Central California Coast Range	Foothills along west margin of action area	Soils are nearly level to moderately sloping. Most soils are alluvial, although some are residual. Soil textures are generally loamy to clayey; bedrock outcrops and gravelly units are locally present, particularly at higher elevations. Soils range from shallow to moderately deep, and are typically deeper at lower elevations.	Moderate	Moderate to rapid	Moderate to high
17—Sacramento and San Joaquin Valleys	Central portion of action area	Soils are nearly level, and are alluvial, occurring on low terraces, fans, and floodplains, and in basins. Soil textures range from clay to loamy sand. Organic soils are present in the northern (Delta) portion of the action area. Soils are typically very deep.	None to slight	Very slow	Ranges from low to high, depending on soil texture
18—Sierra Nevada foothills	Foothills along east margin of action area	Soils are nearly level to moderately sloping. They are primarily alluvial, although residual soils are present at the highest elevations in this MRLA. Soil textures are generally loamy to sandy, with gravelly and cobbly units locally present. Soils range from shallow to deep.	Moderate	Moderate to rapid	Moderate to high

Source: Earth System Science Center 1998.

The soils in the action area have been mapped by the U.S. Department of Agriculture's Natural Resources Conservation Service (formerly the Soil Conservation Service), and are described in detail in the soil surveys for the action area counties. Additional information is available through the National Soil Survey Geographic (SSURGO) Database and State Soil Geographic (STATSGO) database (Natural Resources Conservation Service 2004b, Natural Resources Conservation Service 2004c).

Geologic Hazards

Primary Seismic Hazards—Surface Fault Rupture and Groundshaking

Within the action area, faults recognized as active by the State of California and zoned pursuant to the Alquist-Priolo Act include, from north to south, the Greenville, Ortigalita, Nuñez, San Andreas, Buena Vista, Kern Front and related structures, Pleito, White Wolf, and Garlock (Figure 7-1). All of these faults pose some risk of surface rupture related to seismic activity.

In addition to possible surface rupture, the action area is likely to experience strong groundshaking as a result of earthquakes on any of the region's principal active faults during the lifespan of the proposed project; in addition to those listed above, faults to consider in assessing the potential for groundshaking effects include the Hayward and Calaveras (Figure 7-1). Recent studies estimate a 62% probability of at least one earthquake with a magnitude of 6.7 or greater occurring on one of the faults of the greater San Francisco Bay Area in the next 30 years, and a 10% probability of a magnitude 7.0 or greater event during the same timeframe (U.S. Geological Survey Working Group on California Earthquake Probabilities 2003). Table 7-2 summarizes current information on earthquake recurrence intervals and maximum credible earthquake (MCE) for key structures in and near the action area.

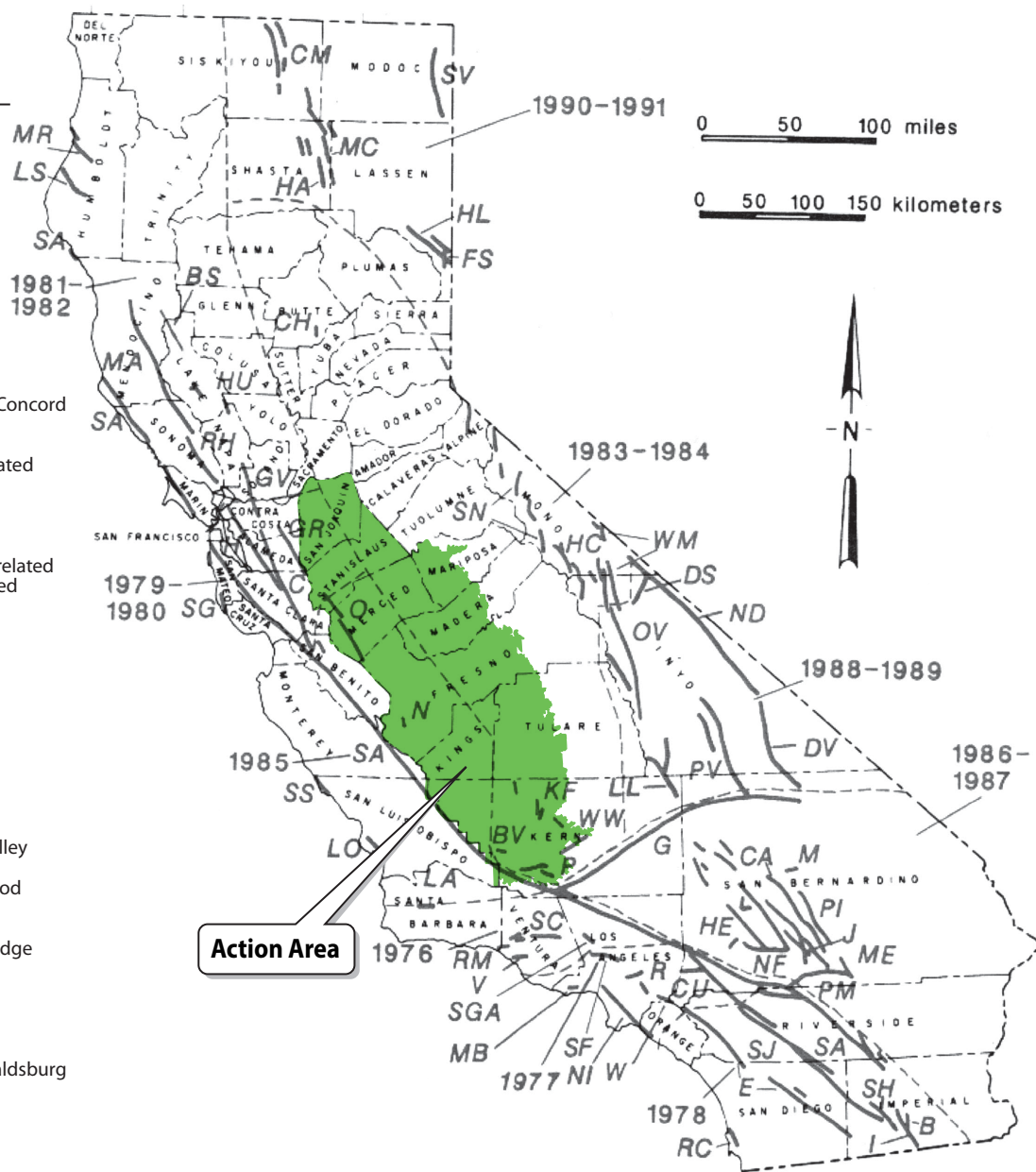
Table 7-2. Maximum Credible Earthquake and Recurrence Interval for Principal Active Faults

Fault	Magnitude of Maximum Credible Earthquake	Approximate Recurrence Interval
Greenville	6.9 ^a	Southern segment: 623 years ^c Northern segment: 644 years ^c
Hayward	Entire fault: 7.1 ^a Southern segment: 6.5 ^a –6.9 ^c	Entire fault: 330 years ^a Southern segment: 161 ^c –167 ^b years
Calaveras (southern)	6.2 ^a	75 years ^c
Ortigalita	6.5–6.75 ^b , 6.9 ^a	2,000–5,000 years ^b
San Andreas	7.0–7.9 ^a	210–400 ^a
Buena Vista	Has been undergoing active creep since about 1930, probably as a result of oil withdrawal ^d	
Kern Front and related faults	Have been undergoing active creep since the 1940s as a result of withdrawal of oil and groundwater ^d	

MAP SYMBOL	NAME OF PRINCIPAL FAULT
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B	*Brawley
BS	Bartlett Springs
BV	*Buena Vista
C	*Calaveras
CA	Calico
CH	*Cleveland Hill
CM	Cedar Mtn.
CU	Cucamonga
DS	Deep Springs
DV	Death Valley
E	Elsinore
FS	*Fort Sage
G	*Garlock
GR	*Greenville
GV	*Green Valley and Concord
H	*Hayward
HA	Hat Creek
HC	*Hilton Creek & related
HE	Helendale
HL	Honey Lake
HU	Hunting Creek
I	*Imperial
J	*Johnson Valley & related
KF	*Kern Front & related
L	Lenwood
LA	Los Alamos
LL	*Little Lake
LO	Los Osos
LS	Little Salmon
M	*Manix
MA	*Maacama
MB	Malibu
MC	McArthur
ME	Mesquite Lake
MR	Mad River
N	*Nunez
ND	Northern Death Valley
NF	North Frontal
NI	*Newport-Inglewood
O	Ortogonalita
OV	*Owens Valley
P	Pleito & Wheeler Ridge
PI	Pisgah-Bullion
PM	Pinto Mountain
PV	Panamint Valley
R	Raymond Hill
RC	Rose Canyon
RH	Rodgers Creek-Healdsburg
RM	Red Mountain
SA	*San Andreas
SC	San Cayetano
SF	*San Fernando
SG	San Gregorio
SGA	San Gabriel
SH	*Superstition Hills
SJ	*San Jacinto
SN	Sierra Nevada (zone)
SS	San Simeon
SV	Surprise Valley
V	Ventura
W	Whittier
WM	*White Mts.
WW	*White Wolf

*Faults with historic surface rupture.



Action Area

Faults zoned through June 1, 1997.

Approximate boundaries of work-plan regions and year studied.

Note: Other faults may be zoned in the future and existing zones may be revised when warranted by new fault data.

Source: Hart and Bryant 1997

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Fault	Magnitude of Maximum Credible Earthquake	Approximate Recurrence Interval
Pleito	6.3–7.3 ^d	Uncertain ^d
White Wolf	6.5–7.5 ^d	Unknown ^d
Garlock	6.8–7.6 ^d	200–3,000 years (differs by segment) ^d

Note: See Figure 7-1 for fault locations.

^aSource: International Conference of Building Officials 1997.

^bSource: Anderson et al. 1982.

^cSource: U.S. Geological Survey Working Group on California Earthquake Probabilities 2003.

^dSource: Southern California Earthquake Center 2004.

The intensity of ground shaking at any given location is a function of earthquake magnitude, distance from the earthquake epicenter, and the nature of the substrate. Based on a probabilistic seismic hazard map that depicts the peak horizontal ground acceleration values exceeded at a 10% probability in 50 years (Petersen et al. 1996), the peak horizontal ground acceleration values for the action area range up to 0.5g (where 1g is equal to 1 gravity or an acceleration of 9.8 meters per second per second). This suggests that the groundshaking hazard in the action area ranges from low to moderate, with lower risks in the eastern and central portions of the action area, and higher risks in the west and south, closer to potential seismic sources.

Secondary Seismic Hazards—Liquefaction and Ground Failure

Secondary seismic hazards refers to liquefaction and related types of ground failure, as well as seismically induced landsliding. As discussed in *Regulatory Framework* above, the State of California maps areas subject to secondary seismic hazards pursuant to the Seismic Hazards Mapping Act of 1990. To date, this effort has focused on areas such as the Los Angeles Basin–Orange County region and the San Francisco Bay region, where dense populations are concentrated along active faults; seismic hazards maps have not been issued for the action area, and no such mapping is planned in the foreseeable future (California Geological Survey 2004). Detailed evaluation of liquefaction hazard is outside the scope of this EIS/EIR analysis. Broadly speaking, however, liquefaction is likely to be a substantial concern in parts of the plan area where soils and sediments are sandy and groundwater is shallow.

In the northern portion of the action area, soils are at least locally highly susceptible to liquefaction, and liquefaction may be associated with lateral spreading and/or differential settlement. Lateral spreading has historically occurred in the northern portion of the plan area and both liquefaction and differential settling probably represent important hazards (Association of Bay Area Governments 2001).

Liquefaction may be a concern elsewhere on the valley floor as well. Coarser alluvial materials along the margins of the action area are typically poorly sorted

and are not likely to pose a great risk of liquefaction or related types of ground failure.

Landslide and Other Slope Stability Hazards

The majority of the action area is situated on flat or very gently sloping topography where the potential for slope failure is minimal to low. In the foothill regions on the action area's west and east margins, landslide risk may be substantially greater. This is a particular concern in the Coast Range foothills, where rugged topography underlain by Franciscan rocks is commonly prone to landsliding and debris flows.

Environmental Consequences and Mitigation Strategies

Methodology for Impact Analysis

Effects related to geology, soils, and associated hazards were analyzed qualitatively, based on a review of soils and geologic information for the action area and on professional judgment. Analysis focused on the proposed action's potential to increase the risk of personal injury, loss of life, and damage to property, including new or upgraded facilities, as a result of existing geologic conditions in the action area. Analysis assumed that PG&E will comply with the requirements of the current UBC, relevant CPUC general orders, IEEE 693 seismic design standards, County General Plan seismic safety standards, and County grading ordinances.

Significance Criteria

For the purposes of this analysis, an impact was considered to be significant and to require mitigation if it would result in any of the following.

- Exposure of people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving
- rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault;
- strong seismic groundshaking;
- liquefaction and other related types of seismically induced ground failure; or
- landslides.
- Substantial soil erosion or loss of topsoil.

- Location of structures on a geologic unit or soil that is unstable or that would become unstable as a result of construction, increasing the risk of on- or offsite landslide or slope failure.
- Location of structures on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (International Conference of Building Officials 1997), creating substantial risks to life or property.

Impacts and Mitigation Measures

Proposed Action

Impact GEO1—Potential for damage to new or upgraded facilities as a result of surface fault rupture. Portions of the action area could be subject to surface fault rupture in the event of an earthquake. Figure 7-1 shows faults recognized as active by the State of California; the corridors along these faults are the portions of the action area likely at greatest risk of surface rupture. O&M activities would not substantially affect risks related to surface fault rupture, and are not discussed further; this analysis focuses on new and upgraded facilities.

Two potential concerns are associated with surface rupture damage to PG&E's facilities: safety risk to personnel working in or around new structures, and cost of repairs. Damage to electrical transmission or distribution infrastructure also carries a corollary risk of service interruption, and of fire should power lines be downed as a result of surface rupture; similarly, damage to natural gas infrastructure could interrupt service or lead to fire or explosion. However, neither of these risks would alter substantially as a result of the proposed action, so no further analysis of this issue is needed.

Both the safety risk to personnel and the potential cost of repairs could increase somewhat under the proposed action as new infrastructure is added incrementally through facilities upgrades and new construction. Under a worst-case scenario, this could represent a significant impact, in part because the infrastructure that would be constructed or installed does not qualify as "structures for human occupancy" as defined by the State of California, and thus is not regulated under the Alquist-Priolo Act. However, precisely *because* new structures would not be "structures for human occupancy," increases in safety risks would be comparatively small.

Moreover, all new facilities would be designed and constructed to meet or exceed relevant CPUC standards and, where applicable (and not in conflict with CPUC requirements), earthwork requirements of the current UBC. Substations would be designed and constructed in conformance with IEEE 693 standards. These codes include a wide variety of stipulations relevant to reducing earthquake-related risk, including foundation and structural design, and structural tolerances. In addition, for some new construction (as required by CPUC), site-specific geotechnical studies would be performed by qualified personnel with appropriate expertise, and facilities design and construction would conform to all further recommendations of these investigations, which could expand on, modify, or

increase the stringency of code requirements, as well as constraining the siting of facilities.

In summary, adherence to CPUC, UBC, and IEEE 693 standards and to recommendations of site-specific geotechnical investigations performed by qualified professionals would reduce the potential for structural damage to facilities and corollary indirect impacts associated with surface fault rupture, including safety risk, to the extent feasible, although it cannot be entirely avoided. **This impact is thus considered less than significant.**

Mitigation Measure—No mitigation is required

Impact GEO2—Potential for damage to new or upgraded facilities as a result of seismic groundshaking. As described in *Affected Environment* above, the action area could be subject to groundshaking as a result of earthquake activity on any of a number of faults (Figure 7-1). Maximum ground accelerations are estimated at 0.5g or less (Peterson et al. 1996), but could be sufficient to damage new or upgraded facilities, raising two potential concerns: safety risk to personnel and cost of repairs. As with surface fault rupture, discussed in Impact GEO1 above, the risk of service interruption would not alter substantially as a result of the proposed action; this issue is not discussed further. In addition, O&M activities would not substantially affect risks related to seismic groundshaking, and are not discussed further; this analysis focuses on new and upgraded facilities.

Both the safety risk to personnel and the potential cost of repairs could increase somewhat under the proposed action, as new infrastructure is added incrementally through facilities upgrades and new construction, and the potential for seismic groundshaking damage could represent a significant impact. However, as discussed above, all new facilities would be designed and constructed to meet or exceed relevant CPUC standards and, where applicable (and not in conflict with CPUC requirements), earthwork requirements of the current UBC. Substations would be designed and constructed in conformance with IEEE 693 standards. As discussed above, these codes include a wide variety of stipulations relevant to reducing earthquake-related risk, including foundation and structure design, and structural tolerances. In addition, for some new construction (as required by CPUC), site-specific geotechnical studies would be performed by qualified personnel with appropriate expertise, and facilities design and construction would conform to all further recommendations of these investigations, which could expand on, modify, or increase the stringency of code requirements, as well as constraining the siting of facilities.

In summary, adherence to CPUC, IEEE 693, and UBC standards and to recommendations of site-specific geotechnical investigations performed by qualified professionals would reduce the potential for structural damage to facilities and corollary indirect impacts associated with strong seismic groundshaking, including safety risks, to the extent feasible, although it cannot be entirely avoided. **This impact is expected to be less than significant.**

Mitigation Measure—No mitigation is required.

Impact GEO3—Potential for damage to new or upgraded facilities as a result of seismically induced liquefaction or other seismic ground failure. As discussed above for potential damage related to seismic groundshaking, parts of the action area are at varying degrees of risk related to liquefaction and other types of seismically induced ground failure. As identified above for surface fault rupture and seismic groundshaking, O&M activities would not substantially affect risks related to seismically induced ground failure, and are not discussed further; this analysis focuses on new and upgraded facilities. Concerns include safety hazard to staff and potential cost of repairs. Because new facilities would not be “structures for human occupancy” as defined by the state of California, the increase in safety risk would be comparatively small. In addition, as identified above, all new facilities would be designed and constructed to meet or exceed relevant CPUC standards. Substations would be designed and constructed in conformance with IEEE 693 standards. In addition, for some new construction (as required by CPUC), site-specific geotechnical studies would be performed by qualified personnel with appropriate expertise, and facilities design and construction would conform to all recommendations of this investigation. Adherence to CPUC, IEEE 693, and (where applicable and not in conflict with CPUC requirements) UBC standards and to recommendations of site-specific geotechnical investigations performed by qualified professionals would reduce the potential for structural damage related to seismically induced ground failure to the extent feasible, although it cannot be entirely avoided. **This impact is considered less than significant.**

Mitigation Measure—No mitigation is required.

Impact GEO4—Potential for damage to new or upgraded facilities as a result of slope failure; potential for construction activities to increase slope failure hazard. Concerns related to slope failure are the same as those identified above for earthquake damage: safety risk to personnel and potential costs of repair. Much of the action area is situated on flat or gently sloping topography where the risk of slope failure is minimal. In areas where slopes are steeper and substantial landslide hazard exists—such as the rugged topography underlain by Franciscan units in the eastern Coast Ranges—adherence to relevant CPUC and/or UBC earthwork standards and recommendations of site-specific geotechnical investigations where these are considered necessary by CPUC would reduce the risk of landslide damage to new or upgraded facilities to the extent feasible. Depending on the nature of the site and the type of facilities being constructed, applicable mitigation approaches could include constraining siting; recontouring or otherwise stabilizing slopes prior to construction; ensuring adequate slope drainage; and/or other approaches. These standards and adherence to the general standard of care for good earthwork and construction practice should also ensure that any new earthwork is properly designed and implemented, such that excavation, grading, or fill placement during O&M or new minor construction does not increase the potential for slope failure. For instance, the UBC specifies maximum permissible gradients for cut (excavated) and fill slopes and requires specific types of investigations and reviews performed by state-licensed professionals if these values are to be exceeded. Consequently, **this impact is expected to be less than significant.**

Mitigation Measure—No mitigation is required.

Impact GEO5—Risks to new or upgraded facilities as a result of construction on expansive soils. Portions of the action area are situated on soils with moderate to high expansion potential. If improperly designed or installed, new and upgraded facilities in these areas could be subject to damage related to shrink-swell behavior. However, as identified above, facilities design and construction would comply with CPUC design and would incorporate recommendations of detailed site-specific geotechnical studies where these are considered necessary by CPUC. Depending on the nature of the facilities and the characteristics of the substrate at the work site, such standards and recommendations could require a variety of mitigation approaches, including specialized foundation design; overexcavation and placement of clean, nonexpansive engineered fill prior to construction; and/or other measures to reduce concerns related to expansive soils, consistent with the prevailing engineering standard of care for civil works. Consequently, **this impact is expected to be less than significant.**

Mitigation Measure—No mitigation is required.

Impact GEO6—Potential for proposed action to result in accelerated soil erosion. Erosion hazard for soils in the action area ranges from slight to moderate (Table 7-1). Activities required for minor construction, including vegetation removal, excavation, grading, and fill placement have the potential to cause accelerated soil erosion, particularly at sites in steeper terrain.

As discussed in Chapter 8 (*Water Resources*), PG&E will continue to implement its existing erosion and sediment control BMPs, described in Chapter 2 (see *Water Quality Program* in *PG&E's Existing Environmental Programs and Practices*). In addition, for minor construction sites that exceed 1 acre, PG&E will be required to prepare a SWPPP pursuant to Section 402 of the federal Clean Water Act. The SWPPP will prescribe procedures and BMPs to control accelerated erosion and sedimentation; will require that the BMPs be monitored to ensure their efficacy until disturbed areas are thoroughly revegetated or otherwise appropriately stabilized; and will identify responsibility for monitoring and maintenance of BMPs. BMPs that may be prescribed by the SWPPP include limiting the area of disturbance; installing sediment barriers; salvaging and reapplying topsoil; seeding for temporary and permanent vegetation; and applying mulch and erosion control blankets until vegetation reestablishes. With PG&E's existing BMPs and additional regulatory protection afforded through the SWPPP requirement, **this impact is expected to be less than significant.**

Mitigation Measure—No mitigation is required.

Impact GEO7—Potential loss of topsoil resources. The operations and maintenance activities enabled by the proposed action would be conducted in or immediately adjacent to existing PG&E rights-of-way (ROWs). Surface soils in existing ROWs have undergone varying degrees of disturbance; even where topsoil is present, these areas do not represent an important topsoil resource, so further disturbance by O&M activities would not result in significant loss of

topsoil. By contrast, minor construction projects could be sited outside existing ROWs, and could have footprints of several acres in some cases; some topsoil could be lost as a result of construction under these activities. AMMs implemented under the proposed HCP, such as stockpiling topsoil for use in revegetation, would help to offset losses but would not address loss of the soil profile within the footprint of new infrastructure. However, most if not all new facilities would be constructed near existing infrastructure, and some of the sites would likely be disturbed, offering little topsoil value. Construction on sites contiguous with open space or agricultural land could result in loss of undisturbed topsoil resources, but **losses would be small, and are expected to be less than significant on an activity-by-activity basis.**

Mitigation Measure—No mitigation is required.

Alternative 1—HCP with Reduced Take

Alternative 1 would enable the same program of O&M and minor construction activities as that described for the proposed action, with minor differences specific to commitments for the protection of biological resources. The same program of BMPs, and the same regulatory protection including codes and standards, would continue to apply. Consequently, impacts related to geology and soils would be essentially the same under Alternative 1 as those described for the proposed action.

Alternative 2—HCP with Enhanced Compensation

Alternative 2 would enable the same program of O&M and minor construction activities as that described for the proposed action. Differences between Alternative 2 and the proposed action would center on compensation ratios for habitat disturbed or lost (increased under Alternative 2 by comparison with the proposed action). As with Alternative 1, the same program of BMPs and the same regulatory protection, including codes and standards, would continue to apply. Thus, impacts related to geology and soils would be essentially the same under Alternative 2 as those described for the proposed action.

Alternative 3—HCP with Reduced Number of Covered Species

Alternative 3 would enable the same program of O&M and minor construction activities as that described for the proposed action. The key difference between Alternative 3 and the proposed action would relate to the number of species covered under the Alternative 3 (reduced by comparison with the proposed HCP, as described in Chapter 2). As described for the other action alternatives, the same program of BMPs and the same regulatory protection, including codes and standards, would continue to apply. Impacts related to geology and soils would

be essentially the same under Alternative 3 as those described for the proposed action.

Alternative 4—No Action

Under the No Action Alternative, PG&E would continue its existing program of O&M and minor construction activities unchanged. No HCP would be implemented, and no other new environmental commitments would be put in place. However, as identified for the three action alternatives, the same program of BMPs and the same regulatory protection, including codes and standards, would continue to apply under the No Action Alternative. Impacts related to geology and soils would thus be essentially the same under Alternative 4 as those described for the proposed action.

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